

## ETCHING PROCESS AND PATTERNING PROCESS

### DESCRIPTION

#### BACKGROUND OF THE INVENTION

[Para 1] Field of the Invention

[Para 2] The present invention relates to an etching process. More particularly, the present invention relates to an etching process that includes a step of removing the polymer generated in the etching step of the bottom anti-reflection coating (BARC), and relates to a patterning process including the etching process.

[Para 3] Description of the Related Art

[Para 4] As the IC industry advances rapidly, the dimension of devices is continuously reduced to make higher and higher integration degree. When the process linewidth is down to less than  $0.13\mu\text{m}$ , the KrF-248nm lithography techniques are no more suitable, and ArF-193nm lithography techniques are used instead. However, since light having a shorter wavelength has higher reflectivity at the interface of the photoresist layer and the die, the resulting photoresist patterns are distorted more easily. The problem is even more significant when a layer of high-reflectivity material, such as, polysilicon or metal like aluminum, is to be patterned, since the degree of pattern distortion increases with the intensity of the reflective light. Accordingly, when the process linewidth is small and the reflectivity of the film to be patterned is high, controlling the critical dimension is particularly difficult.

[Para 5] Conventionally, the issue of reflective light is solved by forming a bottom anti-reflection coating (BARC) on the material layer to be etched prior to the photoresist layer. After the photoresist layer is patterned with a lithography method, the BARC is etched/patterned using the patterned photoresist layer as a mask. Then, the material layer is etched using the patterned photoresist layer as a mask, so that the photoresist patterns are transferred to the material layer.

[Para 6] However, during the etching step of the BARC, polymer as an etching by-product is usually deposited on the patterned photoresist layer, so that the photoresist patterns are changed and the pattern linewidth is increased. Therefore, in the latter step of etching the material layer, the patterns transferred to the material layer and the critical dimension thereof are not correct.

## SUMMARY OF THE INVENTION

[Para 7] In view of the foregoing, this invention provides an etching process that includes a polymer removal step to keep the critical dimension unchanged and make the pattern transfer accurate.

[Para 8] This invention also provides a patterning process that includes the above etching process and therefore has the same effects.

[Para 9] The etching process of this invention is described as follows. A material layer having a bottom anti-reflection coating (BARC) and a patterned photoresist layer thereon is provided. An etching step is performed to the BARC using the patterned photoresist layer as a mask, wherein polymer as an etching by-product is formed on the patterned photoresist layer. A cleaning step is performed to remove the polymer from the patterned photoresist layer. Thereafter, another etching step is performed to the material layer using the patterned photoresist layer as a mask.

[Para 10] According to a preferred embodiment, the above cleaning step can utilize an ionized gas to remove the polymer. The ionized gas preferably has a higher etching rate to the polymer than to the material layer.

[Para 11] In addition, the material layer may be a polysilicon layer. When the material layer is a polysilicon layer, the ionized gas preferably contains fluorine ions, oxygen ions or a combination thereof.

[Para 12] Moreover, the above bottom anti-reflection coating may include an inorganic material or an organic material.

[Para 13] Furthermore, the patterned photoresist layer can be trimmed to reduce its linewidth after the material layer having the patterned photoresist layer thereon is provided.

[Para 14] Since the polymer generated in the etching step of the BARC is removed in the subsequent cleaning step, the photoresist patterns can be accurately transferred to the material layer in the latter etching step of the material layer.

[Para 15] The patterning process of this invention includes the above-mentioned etching process of this invention. A BARC and a photoresist layer are formed on a material layer, and the photoresist layer is patterned using a lithography method. The patterned photoresist layer is then trimmed, and an etching step is performed to the BRAC using the patterned photoresist layer as a mask, wherein polymer as an etching by-product is formed on the patterned photoresist layer. A cleaning step is performed to remove the polymer from the patterned photoresist layer. Then, another etching step is performed to the material layer using the patterned photoresist layer as a mask. Among the above steps, the two etching steps and the cleaning step can be performed in-situ.

[Para 16] According to a preferred embodiment, the above cleaning step can utilize an ionized gas to remove the polymer. The ionized gas preferably has a higher etching rate to the polymer than to the material layer.

[Para 17] In addition, the material layer may be a polysilicon layer. When the material layer is a polysilicon layer, the ionized gas preferably contains fluorine ions, oxygen ions or a combination thereof.

[Para 18] Moreover, the above BARC can include an inorganic material or an organic material.

[Para 19] Since the linewidth of photoresist patterns is reduced with the trimmed step and the polymer generated in the subsequent etching step of the BARC is removed, the linewidth of the patterns transferred to the material layer can be reduced.

[Para 20] It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[Para 21] FIGs. 1A-1E schematically illustrate a patterning process including an etching process according to a preferred embodiment of this invention in a cross-sectional view.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[Para 22] Referring to FIG. 1A, a substrate 100 having a material layer 102 to be etched thereon is provided, and a BARC 104 is formed on a material layer 102.

[Para 23] The material layer 102 may be a polysilicon layer.

[Para 24] The BARC 104 may include an inorganic material or an organic material. The inorganic material can be formed with chemical vapor

deposition (CVD), and may be amorphous carbon, silicon nitride, silicon oxynitride or titanium oxide.

[Para 25] Referring to FIG. 1B, a patterned photoresist layer 107 is formed on the BARC 104. The method for forming the patterned photoresist layer 107 may include the following steps. A photoresist layer is formed on the BARC 104 with spin-coating and baking, and is then patterned using a lithography method. The material solution for coating the photoresist layer includes a resin, a solvent and a photosensitive agent.

[Para 26] Referring to FIG. 1C, an etching step 108 is performed to the BARC 104 using the patterned photoresist layer 107 as a mask, so as to form a patterned BARC 104a.

[Para 27] As shown in FIG. 1C, during the etching step 108, a polymer layer 110 as an etching by-product is formed on the patterned photoresist layer 107. The polymer layer 110 will reduce the accuracy of the pattern transfer to the material layer 102 and increase the critical dimension of the patterned photoresist layer 107.

[Para 28] Referring to FIG. 1D, a cleaning step 112 is conducted to remove the polymer layer 110 from the patterned photoresist layer 107.

[Para 29] The cleaning step 112 preferably utilizes an ionized gas to remove the polymer layer 110. The ionized gas preferably has a higher etching rate to the polymer than to the material layer 102, so that the material layer 102 is substantially not damaged.

[Para 30] For example, when the material layer 102 is a polysilicon layer, the ionized gas preferably contains fluorine ions, oxygen ions or a combination thereof.

[Para 31] Referring to FIG. 1E, after the cleaning step 112 is conducted, an etching step 114 is performed to pattern the material layer 102 using the patterned photoresist layer 107 as a mask. A patterned material layer 102a is thus obtained.

[Para 32] Since the cleaning step is performed to remove the polymer layer 110 from the patterned photoresist layer 107 before the material layer 102 is

etched, the photoresist patterns can be accurately transferred to the material layer 102, and the critical dimension is not affected.

[Para 33] Moreover, after the patterned photoresist layer 107 is formed, it can be trimmed to reduce its linewidth, wherein plasma may be used to isotropically etch the patterned photoresist layer 107. Alternatively, the trimming step can be done with a solution that can etch the patterned photoresist layer 107 isotropically to reduce its linewidth.

[Para 34] Furthermore, in another preferred embodiment, the step of trimming the patterned photoresist layer 107, the etching step 108 of the BARC 104, the cleaning step 112 and the etching step 114 of the material layer 102 can be performed *in-situ*. Specifically, when the step of trimming the patterned photoresist layer 107 and the cleaning step 112 both utilize dry-etching methods like plasma etching, the four steps can be conducted in the same dry-etching chamber or machine. Thus, the fabrication process can be simplified, and damages to the wafer due to transportation between different machines can be prevented.

[Para 35] In summary, this invention includes a cleaning step for removing the polymer generated in the etching step of the BARC, so that the photoresist patterns can be transferred accurately and the critical dimension can be kept unchanged. Moreover, a trimming step can be performed to reduce the linewidth of the patterned photoresist layer after the patterned photoresist layer is formed.

[Para 36] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention covers modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.